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Applicant (Actual Inventor)	Clifton Keith Elliott.
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Complete Specification after Provisional Specification	Lodged, 22nd January, 1938.
Complete Specification	Accepted, 23rd March, 1938.
Acceptance Advertised (Sec. 50) ..	7th April, 1938.

Class 96.5.

Drawing attached.

COMPLETE SPECIFICATION.

"Improvements in and relating to direct-acting hydraulic shock-absorbers for motor vehicles."

I, Clifton Keith Elliott, of 38 Kambala Road, Bellevue Hill, in the State of New South Wales, Commonwealth of Australia, Manager, hereby declare this invention and the manner in which it is to be performed, to be fully described and ascertained in and by the following statement:—

This invention relates to hydraulic shock-absorbers of the direct-acting type for use on motor vehicles to control the compression and rebound flexure of the suspension springs of the vehicle. Shock-absorbers of this general type are described in Commonwealth Patent Specification No. 3817/*36*, and in such shock-absorbers the control on the springs is obtained by the control of the flow of oil from one chamber to another of the shock-absorber during flexure of the springs.

In known shock-absorbers of this type the flow of oil between the two chambers, to control the spring movement, is regulated by a relief valve and by the capacity of a relief passage, but as the capacity of this passage is constant, the resistance to the oil flowing through the passage is constant in any displaced position of the shock-absorber, and consequently the desired control or damping of the springs is not obtained.

The principal object of this invention is to provide a double acting shock-absorber of the stated type, in which a progressively increasing resistance is applied to displacement of the shock-absorber as the limit of its displacement in either direction is approached. In this manner but little resistance is offered to the initial flexure of the vehicle spring at the commencement of such flexure, but the resistance increases progressively with the amplitude of the flexure, at least after a certain displacement has occurred. By this means, considerably more effective damping of the spring flexure in either direction is obtained.

A further novel object of the invention is to provide a definite limit, by hydraulic locking, to displacement of the shock-absorber, and consequently to flexure of the springs. As a consequence, a metal-to-metal stop, with its attendant risk of fracture of the units, is avoided. This hydraulic limit is reached through gradually increasing pressure until further transferrance of the oil is cut off, and no further displacement of the shock-absorber can occur. The limiting position may be readily adjusted to retain spring flexure within any desired limits.

1649.—28/4/38.—130.—Price, 1s. 6d. post free.

Other advantages over known shock-absorbers of this type are the low temperature of the oil which is obtained by extensive circulation, simplicity and accessibility of the valves, and an improved column support for the two telescoping units of the shock-absorber which results from the fact that the units are telescoped to a high degree before considerable pressure is applied.

In order to fully describe the invention reference is made to the accompanying drawings which depict a preferred embodiment of the invention, and a modified form thereof, and in which:—

Fig. 1 is a longitudinal elevation in part cross-section, through the shock-absorber in the normal position,

Fig. 2 is a similar view in a semi-compressed position,

Fig. 3 is a similar view in the fully compressed position,

Fig. 4 is a broken detailed cross-sectional elevation of the shock-absorber, in the fully compressed position, and at right angles to the views of Figs. 1, 2 and 3,

Fig. 5 is a cross-sectional elevation on the line 5—5 of Fig. 4,

Fig. 6 is a cross-sectional plan view on line 6—6 of Fig. 4, and

Fig. 7 is a longitudinal cross-sectional elevation of a modified form of the shock-absorber.

As shown more particularly in Fig. 4, the shock-absorber comprises an upper head 8 and a lower head 9, which are fitted for attachment respectively to the chassis and sprung undercarriage of the motor vehicle, in known manner.

Into lower head **9** is threaded the lower end of a hollow oil tube **10**, over the upper end of which is screwed a piston **11**, which slides in a tube **12** welded on to upper head **8**. Tube **12** is closed at its lower end by piston head **13** which is a neat sliding fit about oil tube **10** and slides with clearance in tube **14**, which is threaded on to lower head **9** and telescopes (with clearance) over tube **12** on which it is sealed by washer **15**.

Piston **11** and piston-head **13** form between them a secondary compression chamber **16** between tubes **10** and **12**; piston-head **13** and lower head **9** form between them a primary compression chamber **17** within tube **14**; and piston **11** and upper head **8** form between them a vacuum chamber **18** within tube **12**.

A tube **19**, welded on to lower head **9**, forms about tube **14**, and an upper part of tube **12**, an oil reservoir **20** which is fitted with a filling plug **20¹**: Tube **19** is slidably sealed on to tube **12** by means of an annular "L" leather **21** which is clamped between a retaining ring **22**, seating on an annular rib **23** on the inner surface of tube **19**, and a retaining ring **24** threaded into the upper end of tube **19**.

A dust-cover tube **25**, welded on to upper head **8**, telescopes over reservoir tube **19** with a clearance, and the ingress of dust is prevented by a felt washer **26** clamped between the upper end of reservoir tube **19** and the retaining ring **24**.

A chamber **27** within piston **11** is in open communication with the bore **10¹** of tube **10**, and this chamber **27** communicates with compression chamber **16** through one-way ball valves **28, 28** retained on their seats by springs **29, 29** which are maintained in position by a washer **30** about tube **10**. A one-way ball valve **31** permits a return flow of leakage oil from vacuum-chamber **18** to piston chamber **27**, and this valve is retained on its seat by spring **32** mounted on a pin **33** disposed across piston **11**.

Reservoir **20** communicates with a cross-bore **34** in lower head **9** by means of a plurality of ducts **35, 35**. The bore **10¹** of oil-tube **10** communicates with cross-bore **34** past a one-way ball valve **36** maintained on its seat by a spring **37**. Cross-bore **34** communicates with compression chamber **17** by ducts **38, 38** past one-way ball valves **39, 39** maintained on their seats by gravity, and retained in place by washer **39¹** about tube **10**.

Oil tube **10** has formed on its outer surface, at diametrically opposite positions, two longitudinal oil grooves **40, 40**. These grooves are shewn in side elevation in Fig. 4, in front elevation in Figs. 1 to 3 inclusive, and in cross-section in Fig. 6. The grooves **40, 40** are tapered from a starting point **41** adjacent the upper end of the tube, to the deepest point, at which three spaced leakage apertures **42, 42** are formed in the wall of tube **10** connecting the grooves **40** with the bore **10¹** of the tube **10**. From the deepest point the grooves **40, 40** gradually run out to a vanishing point **43** adjacent the lower end of the tube **10**, but spaced from such lower end. The distance from the starting point **41** to the deepest point **42** is greater

than the distance from the vanishing point 43 to the deepest point 42. Tube 10 is fitted with two soft metal blow-out safety plugs 10^2, 10^2.

The illustrative Figures 1 to 3, shewing the shock-absorber in various stages of compression, should be read in conjunction with Fig. 4 which illustrates in more detail the transfer of oil which controls the function of the shock-absorber. The operation of the shock-absorber is as follows:—

Presume that the shock-absorber is charged with oil, that is that compression chambers 16 and 17, oil tube 10, piston chamber 27, and the ducts in the lower head 9 are fully charged, and that some excess oil remains in reservoir 20.

Fig. 1 shews the shock-absorber in the normal uncompressed condition. When the vehicle wheel rises upon impact with a road irregularity, the heads 8 and 9 are forced towards each other, and the tubes mutually telescope. Lower head 9 and piston 11 commence to move upwardly in relation to upper head 8 and piston-head 13, which results in the oil in primary compression chamber 17 being placed under compression, and a negative pressure being established in secondary chamber 16.

Oil is therefore forced to flow from chamber 17 through leakage apertures 42 into the bore 10^1 of oil tube 10, whence it passes into chamber 27 in piston 11 and thence past ball valves 28, 28 (which are forced off their seats) into chamber 16, to charge the increasing volume of that chamber with the oil displaced from chamber 17, which is decreasing in volume. As oil tube 10 rises through piston head 13, the upper end of oil grooves 40 enter chamber 16 and present bye-passes, so that oil is also transferred through the grooves 40 directly from chamber 17 to chamber 16. As oil tube 10 continues to rise, the cross-sectional area of grooves 40, 40 progressively increases, so that a progressively reducing resistance is offered, during this extensive initial movement, to the compression of the shock-absorber.

When, however, the compression has proceeded to the point (Fig. 2) where the leakage apertures 42, 42 pass under piston head 13, the escape of oil into the bore 10^1 of tube 10 is progressively cut off, so that the resistance to the escape of oil is progressively increased. It will be evident that when the compression has proceeded to a point where all the leakage apertures 42, 42 have passed under piston head 13, the only escape for the oil from chamber 17 into chamber 16 is by grooves 40, 40. But as the end of the compression displacement is approached, grooves 40, 40 progressively diminish in area, and the resistance to compression correspondingly progressively increases.

When the position shewn in Fig. 3 is attained, piston head 13 has reached the end of grooves 40, and consequently no further oil can escape from chamber 17. This position is the end of the compression displacement, and the compressed oil remaining in chamber 17 constitutes an hydraulic lock which limits the compression without metal-to-metal contact. The position of the ends 41 and 43 of grooves 40 determines the maximum displacement of the shock-absorber.

The volume of chamber 16 is slightly less than that of chamber 17, owing to the difference in diameters of tubes 12 and 14, and any oil which is displaced from chamber 17 and which cannot be accommodated in chamber 16, is passed from bore 10^1 of oil tube 10 past ball valve 36 into cross-bore 34 and thence by ducts 35 into reservoir 20.

Also, during ascending movement of piston 11, leakage-oil which may have found its way into vacuum chamber 13 is forced, by compression in that chamber, past ball valve 31 into piston chamber 27, so that chamber 18 is constantly evacuated of oil and air.

When the vehicle spring commences its rebound movement (from the position of Fig. 3) which it is essential to damp, upper head 8, tubes 12 and 25, and piston head 13 commence to move upwardly in relation to the other parts, necessitating a re-transfer of oil from chamber 16 to chamber 17. As piston head 13 slides upwardly over oil tube 10 (from the position of Fig. 3), grooves 40, 40 are progressively uncovered and a reducing resistance is applied to the initial return flow of the oil from chamber 16 through the grooves and into chamber 17, whilst simultaneously oil is forced from chamber 16, via apertures 42 to the bore of tube 10, whence it flows past valve 36 to the reservoir 20.

The point of lowest resistance is reached as piston head 13 commences to slide upwardly over apertures 42, as thereafter the

only escape of oil from chamber **16** to chamber **17** is by the grooves **40**, **40** which are gradually and progressively reduced in cross-sectional area, thereby imposing a progressively increasing resistance against the spring rebound as the normal position is approached. When the piston head **13** runs to the upper ends **41** of grooves **40**, no further flow of oil from chamber **16** can take place, and the movement ceases under an hydraulic lock in chamber **16**, as shewn in Fig. 1.

It will also be observed that as the zone of minimum resistance (the apertures **42**, **42**) is further from the upper end **41** of grooves **40** than from the lower end **43** thereof, a longer period of increasing resistance is offered to the rebound of the springs than is offered the initial compression thereof, which fulfils the condition for most effective spring control.

Throughout the rebound movement additional oil, to keep chamber **17** fully charged, is drawn from reservoir **20** through cross-bore **34**, ducts **38** and ball valves **39**.

The modified construction illustrated in Fig. 7 differs from that abovedescribed only in the construction of the oil tube **10**³. In this construction the oil tube is formed along its length with a series of spaced leakage apertures **42**¹, **42**¹, which series of apertures terminates short of the piston **11** and lower head **9** in order to provide the hydraulic lock (abovedescribed) at either end of the displacement of the shock-absorber.

The operation of this modified form is identical with that previously described, except that all the oil transferred between chambers **16** and **17** passes through the bore **10**¹ of oil tube **10**³, and that the resistance against displacement of the shock-absorber is progressively increased in steps in place of a continuous increase.

It will be appreciated that as the shock-absorber is displaced from the normal position (Fig. 1) oil is forced to flow from chamber **17** into the bore **10**¹ of oil tube **10**³, through the large number of apertures **42**¹ at that time in register with that chamber, and thence into chamber **16** through piston chamber **17**, and through any apertures **42**¹ at that time in register with chamber **16**. It will therefore be evident that but little resistance is presented to the transferrance of oil at this time, but as oil tube **10**³ ascends through piston head **13**, the number of leakage apertures **42**¹ in communication with chamber **17** is reduced, and consequently the resistance against the flow of oil from chamber **17** is increased in steps. The maximum displacement is reached when oil tube **10**³ ascends through piston head **13** to a point where the lowest aperture **42**¹ passes thereunder, at which point the hydraulic lock in chamber **17** is established.

On the rebound movement of the shock-absorber the oil is re-transferred from chamber **16** to chamber **17** in exactly the converse manner. Thus the resistance to displacement of the shock-absorber in either direction increases progressively in steps from the beginning to the end of each displacement.

It will be appreciated from the foregoing description that the invention provides a shock-absorber of the stated type in which a progressively increasing resistance is offered to displacement of the shock-absorber as the end of the displacement in either direction is approached. This increasing resistance is caused by the progressive diminution of the cross-sectional area of oil grooves **40**, and in the modified form, by the diminution of the number of escape apertures, in communication with the compression chamber from which the oil is flowing. In the construction of Fig. 3, which has oil grooves **40**, the resistance does not commence to increase until after a certain displacement of the shock-absorber has taken place. In the construction of Fig. 7, however, the resistance increases throughout the displacement. This feature of increasing resistance results in very effective damping of the vehicle springs, which cannot be obtained with constant-resistance constructions.

Furthermore, an hydraulic lock in chambers **16** and **17** is obtained at the ends of the displacement in either direction respectively, so that no metal-to-metal stop is necessary. Moreover, variation of the position of the ends **41** and **43** of grooves **40** permits a simple means of controlling the extent of spring flexure.

The tubes are well telescoped before the resistance increases to a high degree, and consequently the units constitute a strong column which is not likely to collapse under severe stress. Further, the oil is circulated into and from the reservoir **20** during operation, as a result of which much of the oil heat is dissipated, and the oil temperature remains within safe limits.

Having now fully described and ascertained my said invention and the manner in which it is to be performed, I declare that what I claim is:—

1. A shock-absorber of the stated type in which oil is transferred from one chamber to another on displacement of the shock-absorber, characterised in that a progressively increasing resistance is applied to such transferrance of the oil as the limit of the displacement is approached.

2. A shock-absorber of the stated type in which oil is transferred from one chamber to another on displacement of the shock-absorber, in which such transferrance is partially or wholly through a tube communicating with both chambers, and in which a progressively increasing resistance is applied to such transferrance as the limit of the said displacement is approached.

3. A shock-absorber of the stated type, and including two chambers constituted by two telescoped tubes each closed at one end and by two mutually displaceable pistons associated with said tubes, and a hollow oil tube disposed through both chambers, characterised in that on displacement of the shock-absorber oil is transferred from one chamber to the other, partially or wholly through said tube.

4. A shock absorber according to any of the preceding claims, in which the transferrance of the oil from one chamber to the other is effected partially through a hollow oil tube in communication with both chambers, and partially through an oil groove formed in the outer surface of the hollow tube and communicating with both chambers.

5. A shock-absorber of the stated type including two pressure chambers constituted by two telescoped tubes each closed at one end and by two mutually displaceable pistons, a tube disposed through both chambers, and an oil groove formed in the outer surface of the oil tube and communicating with both pressure chambers for the transferrance of the oil from one pressure chamber to the other along the groove.

6. A shock-absorber according to Claim 5, in which the oil tube is hollow, and is in communication with both pressure chambers, further characterised in that a proportion of oil is transferred from one pressure chamber to the other through the hollow oil tube.

7. A shock-absorber according to any of Claims 4, 5 or 6, in which a section of the oil groove is progressively reduced in cross-sectional area towards one end where it runs out to zero, in order to apply a progressively increasing resistance to the transferrance of the oil from one chamber to the other as the limit of the displacement of the shock-absorber is approached.

8. A shock-absorber according to any of Claims 4, 5, 6 or 7, in which the oil groove has a zone of maximum cross-sectional area intermediate its ends, and is progressively reduced in cross-sectional area towards its ends where it runs out to zero, in order to apply a progressively increasing resistance to the transferrance of oil as the limit of the displacement of the shock-absorber in either direction is approached.

9. A shock-absorber according to any of Claims 4 to 8 inclusive, in which the oil tube is hollow and is in communication with both chambers, and the oil groove is in communication with the bore of the oil tube.

10. A shock-absorber of the stated type comprising two pressure chambers formed by telescoped tubes and pistons therein, and in which oil is transferred from one chamber to the other on displacement of the shock-absorber in either direction, a hollow oil tube permanently in communication with one chamber and in communication with the other chamber in certain positions of the shock-absorber, an oil groove formed along the outer surface of the oil tube and in communication with both chambers in all but the extreme positions of the displacement of the shock-absorber, and a communication between the oil groove and the bore of the oil tube intermediate the ends of the oil groove, further characterised in that from the commencement of the displacement of the shock-absorber in either direction oil is transferred from one pressure chamber to the other through both the oil groove and the bore of the oil tube, when an intermediate position of displacement is reached the communication of one chamber with the bore of the oil tube is cut off and thereafter the oil is transferred from one chamber to the other entirely through the oil groove until the limit of the displacement is reached.

11. A shock-absorber according to Claim 10, in which the oil groove is formed with

an intermediate zone of maximum cross-sectional area, and from this zone is progressively reduced in cross-sectional area towards both ends, to points where the groove vanishes.

12. A shock-absorber according to Claim 11, in which the oil groove communicates with the bore of the oil tube in the zone of maximum cross-sectional area of the oil groove.

13. A shock-absorber according to any of the preceding claims, in which the resistance to the transferrance of the oil from one chamber to the other, and hence to displacement of the shock-absorber, is progressively reduced from the commencement of the displacement to a point intermediate the ends of such displacement, and that after such point the resistance is progressively increased to the limit of such displacement.

14. A shock-absorber according to Claim 1, in which the oil is transferred between the chambers through a hollow oil tube the bore of which communicates with both chambers by spaced apertures along the tube, characterised in that the number of apertures in communication with one chamber is reduced and the number of apertures in communication with the other chamber is increased during displacement of the shock-absorber, thereby giving an increasing resistance to the transferrance of the oil and to the displacement of the shock-absorber throughout such displacement.

15. A shock-absorber according to any of Claims 2 to 14 inclusive, in which the oil tube is hollow and is in communication with one chamber by means of a one-way valve, to transfer oil from the bore of the tube into that chamber.

16. A shock-absorber according to any of the preceding claims, in which a limit is imposed on the displacement of the shock-absorber in either direction by means of oil locked in one or other of the chambers.

17. A shock-absorber according to any of the preceding claims, in which the maximum volume of one of the chambers is greater than the maximum volume of the other chamber, and including means for transferring oil from the greater chamber, in excess of that transferred to the smaller chamber, into a reservoir.

18. A shock-absorber according to Claim 17, and including means for transferring oil from the reservoir into the greater chamber in addition to that transferred thereinto from the smaller chamber, for the purpose of maintaining the greater chamber filled with oil.

19. A shock-absorber according to any of the preceding claims, which comprises an "upper" head and an inner telescoping tube formed thereon, a "lower" head and an outer telescoping tube formed thereon and disposed over the inner tube, a piston head formed on the end of the inner telescoping tube and forming with the outer telescoping tube and the lower head a pressure chamber, an oil tube secured in the lower head and extending through the said piston head, and a piston on the "upper" end of the oil tube which forms a second pressure chamber with the inner telescoping tube and the piston head thereof.

20. A shock-absorber according to Claim 19, and including a reservoir formed by a tube secured to the "lower" head and enveloping the telescoping tube secured to this head.

21. A shock-absorber substantially as illustrated in Figs. 1 to 6 inclusive, and described in relation thereto.

22. A shock-absorber substantially as illustrated in Fig. 7 and described in relation thereto.

Dated this 21st day of January, A.D. 1938.

CLIFTON KEITH ELLIOTT,
By his Patent Attorney,
STURT GRIFFITH, B.E.
(Griffith, Hassel & Griffith.)

Witness—B. Gawthorpe.

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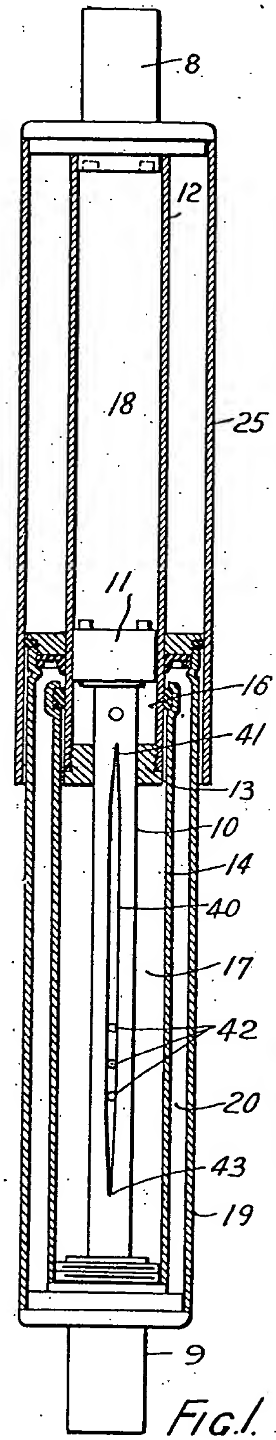


FIG.1.

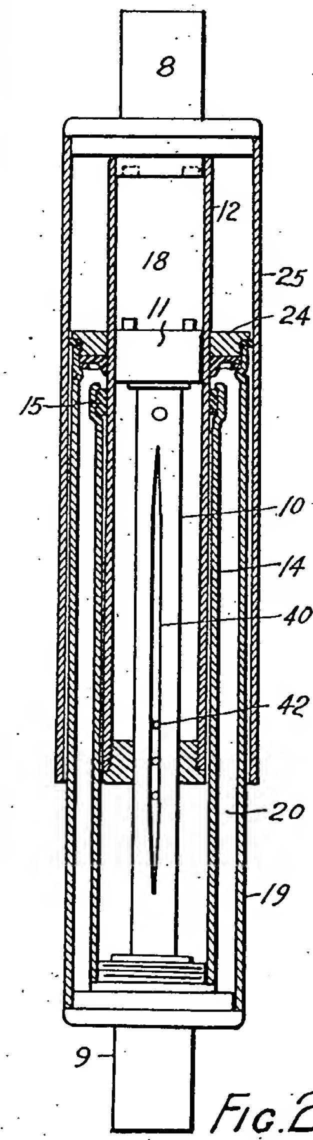


FIG.2.

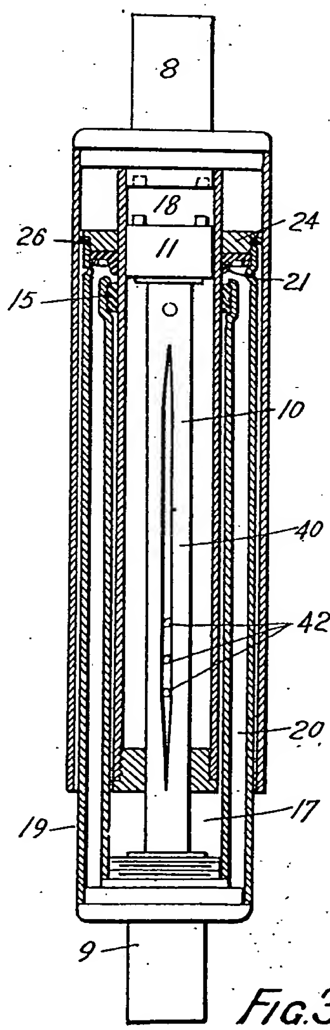
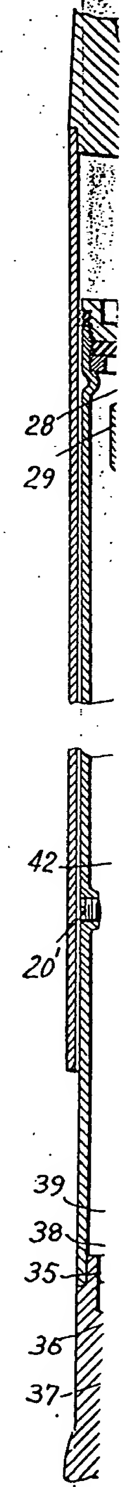


FIG.3.



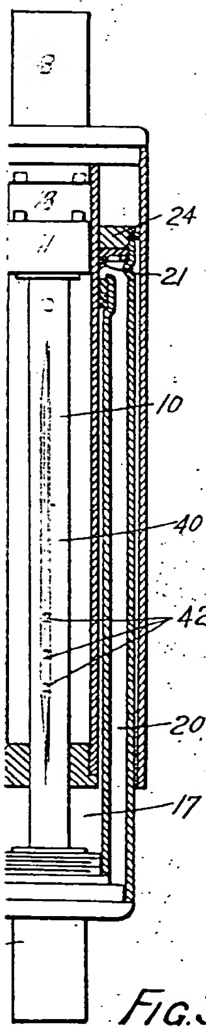


FIG. 3.

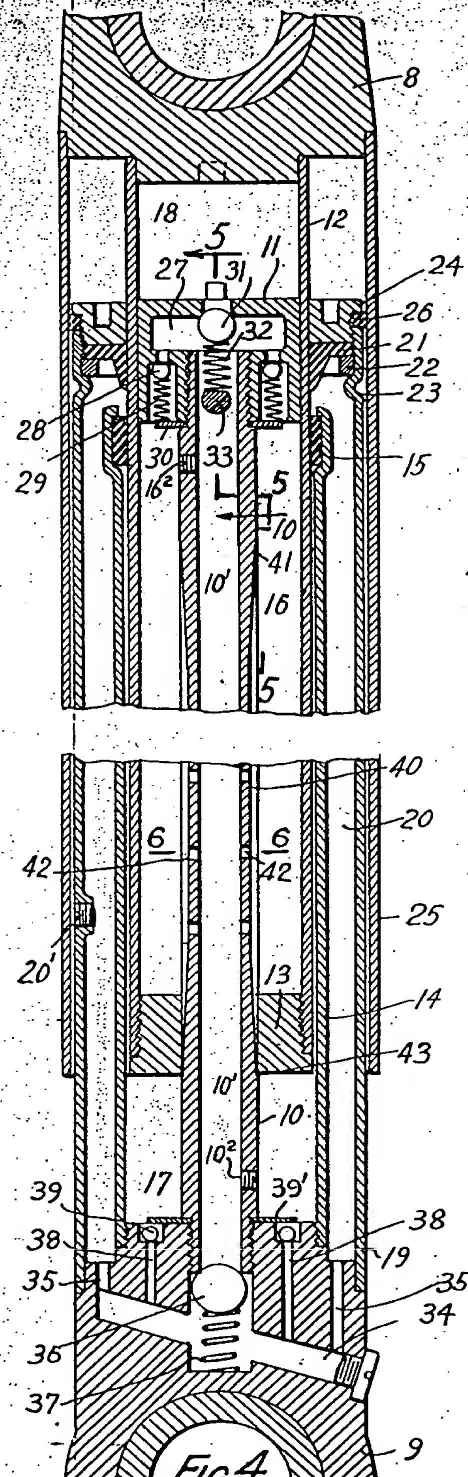


FIG. 4.

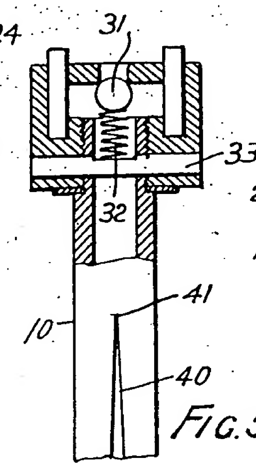


FIG. 5.

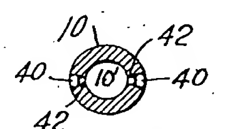


FIG. 6.

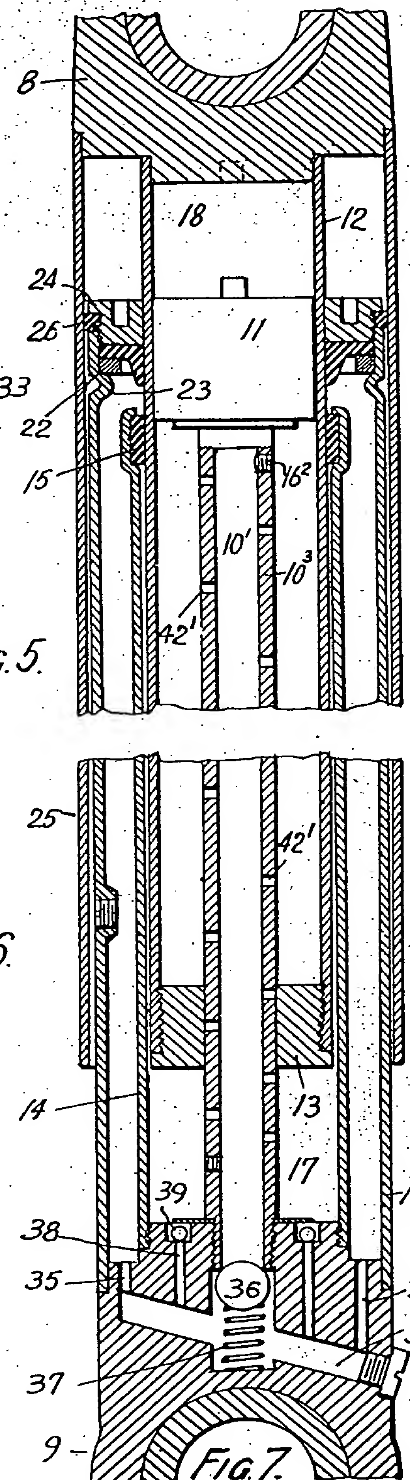


FIG. 7.